WHAT IS RESOURCE ANALYSIS?

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I. INTRODUCTION

In considering the question "What is Resource Analysis?," the fact that resource analysis can have several different meanings should be emphasized at the outset. Depending upon the context of the particular problem at hand, the concepts, analytical methods, and techniques used in a resource analysis can vary considerably. Also, the presentation of results is often very sensitive to the nature of the over-all problem to which the resource analysis is addressed.

Before discussing the question of context in more detail, let us consider briefly the words "resource" and "analysis." Our orientation here is primarily toward governmental decision-making problems, although some of the basic ideas may be applicable elsewhere.

Instead of "resource," we can, and often do, use the word "cost." However, for the purposes of the present discussion, "resource" is probably more descriptive than "cost." Particularly in an economic sense, the word "resource" immediately gets to the heart of the matter, because economic cost implies the use of resources -- manpower, raw materials and the like. Thus in an economic sense, the cost of something is measured by the resources used in attaining that something. Or, more technically, the cost of attaining a certain objective at some point in time is measured by the resources that are not available for use in attaining alternative objectives because these resources are committed to the chosen objective. This concept of cost is based

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upon the fact that a nation's resources are limited, and that therefore we must make choices -- often very difficult choices -- about allocating available resources among competing objectives. If, through some magic, a nation's resources were in fact unlimited, then allocative decisions would be essentially trivial, and we would have little occasion for discussing the subject of resource analysis as we are today.

Another reason for putting the emphasis upon resources is that to many people the word cost implies money cost; and depending upon the circumstances, money cost does not necessarily mean the same thing as economic cost. While in resource analysis we most often ultimately translate physical quantities into dollars, the real objective is to measure the probable "resource drain" on the economy that would result from various possible future courses of action. Dollars are used merely as a convenient "common denominator," so to speak, for aggregating numerous heterogeneous physical quantities and activities into meaningful "packages" for purposes of analysis and decision.

Let us turn now to the word "analysis." Again, an alternative word could be used -- for example "estimating." This term, however, does not necessarily convey the full meaning that is intended here. To many people, "making an estimate" of the cost of something implies taking a detailed set of rather concrete specifications and "pricing out" these given specifications. While such a process is certainly included within our meaning of "resource analysis," a much broader frame of reference is intended.

For one thing, in decision-making contexts involving time horizons extended far into the future, a concrete set of specifications is usually not available. Not only is there a wide range of alternatives to be considered; each alternative, in turn, usually has several possible configurations, and the environment of the problem is characterized by major elements of uncertainty. This being the case, the probable resource impact of all relevant alternatives must be determined, with the objective of finding really significant differences in resource requirements among the alternatives that might be available to perform some specified future task. Also, for any given alternative,

the decision-makers are often interested in a determination of how resource requirements might change as key configuration characteristics are varied over their relevant ranges -- a "sensitivity" type of investigation. All of this implies an analytical type of activity rather than just "cost estimating" per se; hence our preference for the word "analysis."

Another reason is related to the fact that in dealing with future possible courses of action, we are very often concerned with new equipment proposals and new methods of operating such equipments. These new equipments typically have components that have never been produced before, and the operational concepts may be very different from past or current methods of operation. Therefore, the cost of proposed future activities involving the use of these new equipments cannot be determined from a readily available "catalogue" of resource requirements. Information and data on past and current equipment and operations must be obtained; and these data must be analyzed with a view to determining relationships between resource requirements and the characteristics of the equipment and/or key operational variables. If meaningful analytical relationships can be discovered, they are then used as a basis for determining the resource impact of proposed future courses of action. Of course, such relationships must not be applied mechanically; they must be used with discretion and informed judgment. But again, the main point is that a significant amount of analytical type of activity is required.

II. CONTEXT

At times the preceding discussion skirted the boundary of the subject of context. Let us now turn to this question specifically. The matter of context can be discussed under numerous headings. Here, we shall select only three as being illustrative of the total problem. These three are certainly not mutually exclusive; there are many common threads running through all of them. Also, in the discussion to follow the orientation is primarily toward military decision problems, although many of the ideas are applicable to other realms.

The three classifications are:

(1) Time horizon

(2) Decision context

(3) Scope of the problem.

TIME HORIZON

Time horizon is undoubtedly the most important consideration. From it stem the key factors which probably, more than anything else, determine the nature of the concepts, methods, and specific techniques used in tackling a given resource analysis problem. To bring the discussion into focus, let us consider two examples which illustrate the extremes of the time horizon spectrum:

(a) A long-range-planning context in which a "cost-effectiveness" ("systems analysis") type of study is being used to examine systematically the range of alternative weapon system possibilities that might be utilized to perform a certain military mission in a time period some 10 to 15 years from now.

(b) A very short term context in which the problem involves preparation of the operating portion of next fiscal year's military budget.

In (a) we are looking about as far into the future as is usually feasible; and in (b) the time horizon is essentially "tomorrow." Clearly there are numerous marked differences between the two cases. Some of the more important, from a resource analysis point of view, may be summarized briefly as follows (not necessarily in order of relative importance, and certainly not mutually exclusive):

Case (a)	Case (b)
(1) Wide range of alternatives (both for hardware and proposed operational concepts)	(1) Few alternatives (hardware essentially "given")
(2) Great uncertainty	(2) Small degree of uncertainty
(3) Specifications and descriptions of alternatives may be sketchy; paucity of information generally	(3) Detailed descriptions; relatively good information

(4) High degree of accuracy in cost estimates is not possible; emphasis on treating the alternatives consistently	(4) High degree of accuracy required; and is, in general, possible of attainment
(5) Emphasis on comparative or relative costs; looking for major differences in cost among the alternatives to do the specified job	(5) Emphasis on absolute values
(6) Emphasis on presenting results of resource analysis in terms of interest to the long-range planner: "end product" oriented incremental costs	(6) Emphasis on developing and presenting estimates in terms of administrative and implementation oriented categories
(7) Because of wide range of alternatives and high degree of uncertainty, emphasis on developing a range of estimates: "cost sensitivity analysis"	(7) Emphasis on development of "point estimates": limited use of sensitivity analysis
(8) Emphasis on use of generalized estimating relationships	(8) Emphasis on costing out a detailed "set of specifications"

Between the extremes typified by (a) and (b) fall numerous classes of resource analysis problems involving various mixtures of the characteristics listed under (a) and (b). Probably the most significant generalization to be made is that as the time horizon extends into the future, the range of possible alternatives increases and uncertainty becomes greater (at an increasing rate). These factors, more than anything else, determine the structure of a particular resource analysis problem.

DECISION CONTEXT

Decision context is in a sense merely another way of looking at the question of time horizon. By decision context, we mean the three major classes of decision:

(1) Development: Deciding from a wide range of future possibilities which one (or ones) to develop for possible operational use. (Long-range time horizon)

(2) Initiation into service (investment): Deciding from the alternatives under development which one (or ones) to be introduced into the active inventory at a future time period to perform a specified mission or task. (Mid-range time horizon)

(3) Operating: Deciding how to operate systems that are "on hand" in the operational inventory. (Short time horizon)

While these three categories are in effect part of a sequential decision process, they are nevertheless not entirely mutually exclusive. For example, operational considerations often influence "initiation into service (investment)" and even "development" decisions. Also, from a resource analysis point of view, when working in a development decision context, we usually want to assess the "initiation into service" and operating costs as well as the development costs for each of the alternatives under consideration.

Since decision context is essentially another way of looking at the question of time horizon, the lists of characteristics discussed previously are also appropriate here. For example, the characteristics shown under Case (a) apply to "development," those under Case (b) apply to "operating," and "initiation into service" decisions fall somewhere in between (a) and (b).

SCOPE OF THE PROBLEM

Scope of the problem can have several meanings. Here we want to focus on one specific meaning: whether the context is a total force analysis, or whether the context is a limited sub-set of a total force -- e.g., individual weapon systems. While these two contexts are in some sense related, they nevertheless pose somewhat different problems for resource analysis.

If the context is total force, we immediately have the problem of magnitude of the task. A total force is made up of numerous weapon (and support) systems, as well as various "non-system" activities. We have to estimate the time-phased resource impact of all of them. In addition to the mere size of the task, there is the problem stemming from the fact that the numerous components of a total force are often

interrelated. If the analytical methods and techniques used to determine resource impact are not designed to take account of these interactions, the results of the analysis can be seriously in error. Both of these factors -- size and interrelations among the components -- tend to force the development of a total force model which can (at least in part) be automated. Without the use of automatic data processing equipment, it becomes very difficult, if not impossible, to take interactions into account, and to rapidly compute the time-phased resource impact of alternative force structure proposals.

In the case of an individual systems context, the magnitude of the job is much less, although even here the workload can often be substantial. (Recall that a future system proposal may have numerous possible configurations.) The interaction problem is still present. The fact is that the resource impact of a new individual system can vary considerably, depending upon the projected total force context into which the system is assumed to be introduced. This is especially true of facilities and personnel cost. If facilities and personnel are made available ("inherited") from the concurrent phase-out of existing systems at the time when a new system is introduced into the force, the incremental resource impact of the new system will be less than it would be if there were no carryover from other systems.

In principle, one can conclude that to assess realistically the probable incremental resource impact of a new system, the way to proceed is to: (1) determine the resource impact of the total force without the new system; (2) determine the resource impact of the total force with the new system included; and (3) take the difference between (1) and (2). The difference represents the incremental cost of the new system. In practice, however, it is not always possible to take this approach, and less formal methods must be used. The point is that the "interaction" problem should not be ignored in resource analysis of individual systems.

III. IMPACT OF CONTEXT ON CONCEPTS, METHODS AND TECHNIQUES USED IN RESOURCE ANALYSIS

The main theme of this discussion is that the context of the problem is vitally important in determining the specific concepts, methods and analytical techniques used in resource analysis. Let us now examine this matter in more detail, assuming that the context is one of long-range military planning with a time horizon of some ten or more years into the future. The decision context is primarily that of development; although as indicated previously, in considering alternatives in this context the probable resource impact of initiating and operating a new capability is of interest as well as the resource impact associated with developing the new capability. The scope of the problem may be either total force or some sub-set of a total force.

The crux of the long-range military planning problem pertains to the systematic examination of alternative system or force proposals, with a view to finding that alternative (or combination of alternatives) which seems preferable to others. Analytically, this process may take either of two basic forms:

(1) For a specified level of effectiveness in the attainment of a certain national security objective, an attempt is made to determine that alternative or combination of alternatives which is likely to do the job with minimum resource impact.

(2) For a specified budget level to be devoted to a certain area of national security, an attempt is made to determine that system or force proposal (or combination of proposals) attainable from the specified budget which is likely to achieve maximum effectiveness.

In either case, resource analysis is an integral part of the process of selecting "preferred" systems or forces from among the alternatives available for consideration.

Given the context outlined above, what are the major characteristics of a resource analysis capability designed to serve a long-range planning activity? Here, we shall list and discuss briefly some of the more important ones (not necessarily in order of relative importance):

(1) "End product" orientation. Since the long-range planner is typically interested in examining alternative proposals for attaining future military capabilities, the resource analysis process must be structured so that analyses of resource requirements may be generated in terms of "packages" that are meaningful from a planning point of view -- e.g., weapon and/or support systems or some other unit that is associated with military capabilities.

(2) Life cycle identification. Within the structure of an "end product" orientation -- point (1) above -- it is desirable to identify resource requirements in terms of the major "life cycle" phases of a new military capability: development, initiation into the active inventory (investment), and operation over a period of years. This type of identification is also significant from an analytical point of view. Very often we like to manipulate the possible force size and the number of years a new system might be in the operational force. The development/investment/operation segregation facilitates such manipulations.

(3) Resource and/or functional categories. Within the structure of (1) and (2) above, we must set up resource (equipment, facilities, manpower, etc.) and/or functional (maintenance, training, etc.) categories which are meaningful and useful: (a) from a data source and computational standpoint; and (b) from the standpoint of serving to indicate significant areas of resource impact -- special equipment requirements, special manpower skills, etc. -- and to help insure completeness in identifying all required resources. Regardless of what particular set of categories is established, it is vitally important to define carefully what is included in each category. This is a fundamental prerequisite to the development of estimating relationships (to be discussed later) and to help assure consistency in working out the resource impact of alternative system or force proposals.

(4) Appropriate level of detail. Subsidiary to point (3) is the question of the appropriate level of detail. Obviously in a long-range planning context, trying to structure problems in a great amount of detail is undesirable -- indeed it is impossible. However, it is

important to break the problem down into elements which will facilitate determining those aspects of a new system proposal which are really new and those which are not. Even the most advanced system proposals contain many elements which are not significantly new. These should be separated from those which are new, so that the analytical effort can be concentrated on the latter. This is a very important principle for structuring problems in resource analysis.

(5) Explicit treatment of uncertainty. Probably the most significant factor in the context of long-range planning is that of uncertainty. Distant future possible military capabilities are subject to many uncertainties, the most important one being "configuration" or "requirements" uncertainty. Proposals for advanced systems have numerous possibilities with respect to hardware and operational concept configurations, and force size; and at an early stage of development, no one really knows which set of possible characteristics will ultimately prevail. In resource analysis, these uncertainties must not be ignored. Among several possible ways of dealing with uncertainty, one of the most important is to work out the resource impact of numerous sets of system configuration characteristics, thus generating a range of resource impact possibilities rather than a single set ("point estimate"). This leads to a "sensitivity" type of analysis. Sensitivity analysis is useful from several points of view: not only in helping to deal with the problem of uncertainty per se, but also in system preliminary design. It is usually most helpful to have some idea whether total system cost is very sensitive, moderately sensitive, or relatively insensitive to changes in key system parameters as they are varied over their relevant ranges.

(6) The principle of incremental resource impact. In a planning decision context, it is the incremental or net resource requirements that are of interest. While it is true that "sunk costs" (reflecting resources "on hand" that may be used by a new proposed capability) must be taken into account in determining the economic resource impact of the new activity, these "sunk costs" must not be included in the cost for that activity. In principle the procedure is to work out the total requirements, determine the resources that are likely to be

inherited from the phase out of other systems or activities, and subtract these amounts from the total requirements in order to arrive at the net resource requirements for the new system. As indicated previously, this is apt to be most important in the case of facilities and personnel resource categories, and where possible it is best accomplished in the context of a "total force" type of analysis.

(7) Identification of support activities to an "end product" package. Related to the principle of incremental cost is the question of the appropriate identification of "support" type activities with "end product" packages -- e.g., weapon systems or other aggregations of activities useful to the planning process. Some people seem to suggest that the objective should be to identify as much as possible with "end product" activities -- an accounting type allocation or cost distribution concept. From our point of view, this is wrong. The objective should not be to identify as much as possible (often by arbitrary allocations), but rather identify with end product packages only those support activities which are appropriate in view of the context of the problem at hand. In principle this usually means that if a new end product activity is likely to have a significant impact on a particular support operation, the cost of that impact should be identified with the end product activity in question; otherwise, it should not be so identified. In practice, to cite an example in the case of the U.S. Air Force, the operating costs of Headquarters U.S. Air Force, the Air Academy, the Air Finance and Accounting Center, Headquarters Air Force Systems Command, Headquarters Strategic Air Command, and the like, would usually not be identified with Air Force weapon systems. On the other hand the cost of depot maintenance (in Air Force Logistics Command) and certain course costs in the Air Training Command may, and often are, appropriately identified with weapon systems. These ideas apply to both individual system and total force resource analysis. However, it is in a total force context that we see the picture most clearly. Again if we take the Air Force as an example, many Air Force support activities are appropriately identifiable to systems. Others are not related to systems, but rather to a certain mission category (strategic, defense, etc.) as a whole. Still

others are not related to either missions or systems, and are thus treated as "Air Force-wide" activities. In this latter category we find that some activities vary with changes in the total operational force (sometimes in a discontinuous manner); others are essentially insensitive to total force size.

(8) The question of accuracy. The question of accuracy in resource analysis has already been mentioned briefly. It is raised again here because it has an important bearing on the structuring of resource analysis concepts and methods. The key point is that in a long-range planning context characterized by elements of great uncertainty, a high degree of accuracy in an absolute sense is not attainable. This being the case, we should not waste effort in trying to attain something, which by the very nature of the problem is impossible. Furthermore, in many of the more important long-range planning problems, comparisons among a range of alternative future courses of action are of prime interest; and in this comparative type of analysis the resource impact of the alternatives in a relative sense is what is most relevant. Therefore, the orientation in resource analysis concepts and methods should be directed more toward accuracy in a comparative or relative sense rather than an absolute one. This in turn means emphasis on development and use of analytical techniques which will treat alternatives in a consistent and unbiased manner.

(9) Time phasing. In many long-range planning contexts, especially total force analysis, explicit time phasing of resource requirements is a very important consideration. Even in individual weapon systems analyses where the over-all analytical framework does not necessarily require explicit time-phased resource inputs, it is nevertheless often desirable to generate the estimates of resource impact in a time-phased manner. This may not only lead to better estimates, but may also provide the basis for analytical insights into the total problem that might not be readily apparent if the results are presented in a purely "static" form. In general, a resource analysis capability should provide for the generation of estimates of time-phased resource impact in terms of several "concepts of cost" -- e.g., obligational authority, deliveries, and expenditures. It should

also provide for "equalization" ("discounting" for "time preference") of cost streams through time if the context of the problem at hand indicates that the planners are not (or should not be) indifferent with respect to time preference of future resource impacts.

(10) Collection of information and development of estimating relationships. To say that the results of a resource analysis are no better than the information and data going into the analytical effort may seem tautological. Yet this is an important point, and we must face up to the question explicitly. In fact, a really effective resource analysis capability cannot exist without systematic collection and storage of data and information on past, current, and projected programs. Even this is not enough. The data and information must be analyzed with a view to development of estimating relationships which may be used as a basis for determining the resource impact of future proposals. In the case of military systems, these relationships should (ideally) relate various categories of resource impact to system physical, performance, and operational concept characteristics. Without an extensive and continuously updated inventory of estimating relationships, resource analysis as viewed in this discussion is impossible. Such an inventory is particularly a prerequisite to a "sensitivity analysis" approach to the resource analysis problem.

IV. SUMMARY REMARKS

The purpose of this discussion has been to provide a basis for understanding the meaning of "resource analysis." We have pointed out that the specific meaning is heavily dependent upon the context of the particular problem at hand, and we have sketched briefly the main features of several possible contexts.

The remainder of the discussion then attempted to outline the major characteristics of a resource analysis capability designed primarily to serve a long-range planning type of context. While adherence to these characteristics is fundamentally important in developing and operating a resource analysis activity, this alone will not assure good analytical studies. In the final analysis, the results are

heavily dependent upon experience, good judgment, ingenuity in creating and using analytical methods and techniques, and above all just plain hard work.